PROVINCE OF NOVA SCOTIA

DEPARTMENT OF AGRICULTURE

BULLETIN NO. 8.

The Green Apple Bug in Nova Scotia.

—BY—

W. H. BRITTAIN,

Provincial Entomologist.

Published by Order of the Legislature.
January, 1917.

Government of Nova Scotia,

Office of Agriculture.

Truro, N. S., January 1, 1917.

To the Hon. George H. Murray,

Provincial Secretary,

Halifax, N. S.

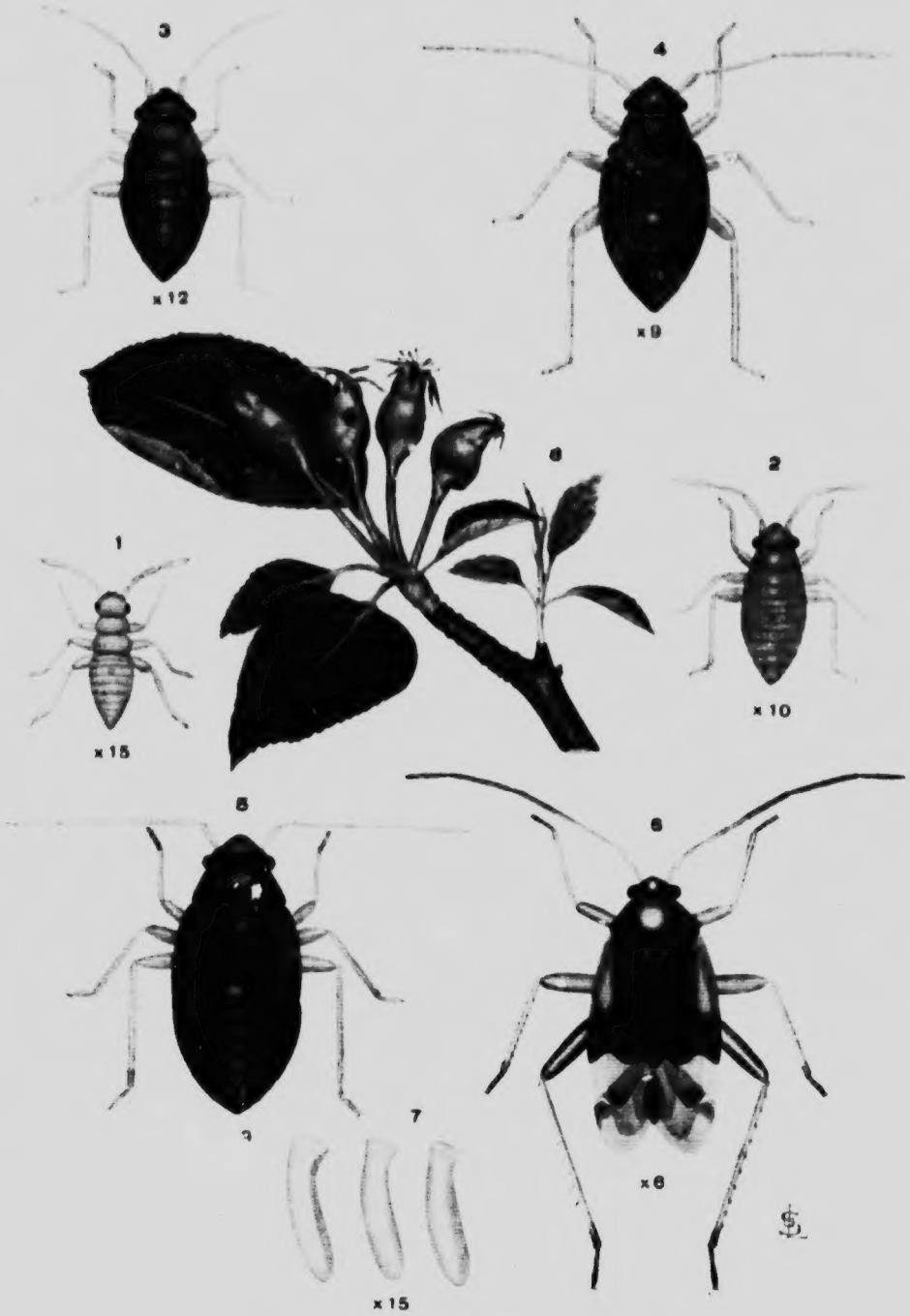
Sir:—I have the honor to transmit Bulletin No. 8, entitled, "The Green Apple Bug in Nova Scotia", and herewith recommend its publication and distribution.

I have the honor to be, Sir,

Your obedient servant,

M. CUMMING,

Secretary for Agriculture.



THE GREEN APPLE BUG

(LYGUS COMMUNIS VAR. NOVASCOTIENSIS KNIGHT)

The Green Apple Bug in Nova Scotia.

— BY —

W. H. BRITTAIN.

EXPLANATION OF COLORED PLATE.—*Figures 1, 2, 3, 4 and 5 represent five successive stages of the nymph or immature insect; figure 6, the adult; figure 7, three of the eggs; figure 8, a fruit cluster bearing young apples punctured by the insect and showing injury to young leaves.*

INTRODUCTION.

The investigation of which this bulletin is the result, has only extended over two seasons. Nevertheless the chief points in the life history of the insect have been worked out, its habits carefully studied, and practical control measures devised. There is, doubtless much still to be learned, but in view of the almost entire lack of available information regarding these matters, it seemed best to offer this information to the public at the present time. The result of further work will be issued in circular form as it is completed.

GENERAL SUMMARY.

1. The Green Apple Bug has been present in Nova Scotia for many years, but has only recently been recognized as being responsible for the damage of which it is the cause.

2. Its injury is widespread in the counties of Hants, Kings, Annapolis and Digby, and it is possibly present in other counties, as well as in the province of Prince Edward Island.

3. It is, where present, the most serious enemy of the fruit-grower, and while not so general as some other pests, the damage that it does is most sweeping and the insect most difficult to eradicate.

4. The insect has only been found to breed on the apple, pear and quince, though in the immature, or nymphal stages, it feeds on various other plants and in the adult state frequently attacks plums.

5. The insect, when newly hatched, resembles a small yellow aphis in appearance though much more active. As it increases in size it becomes bright green and finally reaches the length of one-sixth of an inch. It then moults and assumes the adult or winged form. It is then a fragile insect with relatively long legs and antennae, and in color a combination of light and dark brown. In this stage it closely resembles the common tarnished plant bug (Lygus pratensis Linn.)

6. The young begin to emerge several days before the blossoms open, the maximum emergence coinciding with the period of full bloom of the Bartlett pear, or just as the Gravenstein blossoms begin to open. The nymphal stage is of about 32 days duration. The adults begin to die off within a couple of weeks after reaching maturity, but are found in diminishing numbers throughout the summer and early autumn. The winter is passed in the egg state, beneath the bark of the twigs.

7. The young bugs or nymphs are very active and elusive in their habits and as they increase in size, exhibit an increased tendency to drop to the ground. Leaves, stems, blossoms and fruit are freely attacked, but blossoms and fruit are preferred. They are occasionally predaceous in habit, and though apparently fragile, can exist for several days without food and are able to make their way over the ground for comparatively long distances.

8. The adults are active insects and strong fliers, though, under ordinary conditions, they do not appear to wander far from the orchard in which they have developed. In feeding, the adults prefer a diet of fruit, and that of pears is most attractive to them when they first reach maturity.

9. The first injury to the apples appears as small purple spots upon the leaves, which, as the leaf grows, develop into small perforations. The new succulent shoots are also injured,

and in severe cases wilt and die. The blossoms are freely attacked as soon as they appear, and as a result they also shrivel up and die. Injury to the young fruit is first shown by beads of sap oozing through the skin, later by a reddish pimple, marking the spot. A large proportion of the injured apples drop to the ground, otherwise they are badly scarred and twisted. Continued severe attacks result in a gradual weakening of the vigor of the tree. Injury to the quince resembles that of the apple, but is not so severe.

10. Though the insect breeds on the pear to a certain extent the greatest injury to the fruit of this tree appears to be caused by adults that fly to the pears from infested apples. Their injury cause unsightly brown, corky scars upon the fruit, and hard, flinty kernels extending into the pulp. Such fruit has been popularly known as "woody pears."

11. Plums are also injured by adults flying in from outside, causing an exudation of colorless gum from the infested fruit.

12. Nymphs that fall from the trees are capable of completing their development on various weeds and grasses growing in the orchard.

13. The insect aids in the spread of and increases the losses from European Canker (Nectria ditissima) and is a carrier of Fire Blight (Bacillus amylovorus).

14. Observation and experience has shown that, while of all varieties of apples, the Nonpareil (Roxbury Russet) suffers most severely, others approach it in susceptibility, while none appear to be immune. Among pears Bartletts usually suffer most.

15. Conditions favoring increase are heavy shade, poor air circulation and lack of clean cultivation in the spring and early summer. Destructive outbreaks may occur, however, under a wide range of conditions.

16. Natural enemies have not yet been found to play an important part in the control of the pest, though ants and spiders destroy a certain number.

17. The control of the insect is made difficult by its elusive habits, by its ability to hide in inaccessible places, by the density of the foliage at the time the spraying must be done,

and by the fact that many of the bugs fall off the trees, only to make their way back again after the spraying is finished. The following methods have been found effective:

(a) The trees must be properly pruned and must not be too close together, so that all parts are readily accessible to the spray.

(b) The trees should be banded with tree tanglefoot previous to spraying wherever the insects are numerous, to prevent the reascent of those insects that have fallen to the ground. If the insects could be sprayed within a few days of emergence this would not always be necessary, but owing to the period over which they are emerging, to possible delays due to wet weather, and to the length of time required to spray an orchard of any size, some insects might be well grown before it was possible to spray the whole orchard. Again, if the orchard could be harrowed immediately after spraying banding might be dispensed with, but this is not often possible.

(c) Apple trees should be sprayed with nicotine sulphate (Blackleaf 40) just before the blossoms open, and, if necessary, again just after they fall, using a strength of from ¾ of a pint to 1 pint for each 100 gals. of spray. The weaker strengths may be safely used, especially for the earlier spraying, provided the material is properly applied. Since pears are most seriously infested by adults flying from nearby apple trees, the remedy for pears is, first of all, to spray the infested apples. For pear trees infested by the nymphs, one spray just after the blossoms have fallen is usually sufficient.

(d) A very heavy, drenching, driving spray is necessary, that will reach all parts where the bug is likely to hide. Best results were obtained by the use of a drive nozzle and a pressure of not less than 175 lbs. Spray each limb individually from every angle, taking particular care that the centre and top of the tree is given just as thorough treatment as the outside. Do not be afraid of "wasting spray" or failure is certain to result.

(e) All these precautions if properly carried out, cannot fail to control the pest, but neglect of any one of them may result in complete failure.

HISTORY.

For many years past, so-called "woody pears" have been known and commented upon by fruit growers throughout the Annapolis Valley, such pears being covered with corky disfiguring scars, so as to be rendered quite worthless. This trouble, which has annually destroyed a very large proportion of the pear crop, was commonly ascribed to lack of iron in the soil, and not uncommonly liberal applications of iron filings were made to remedy this condition, but naturally without result.

Within the past ten years an increasing number of orchards that formerly bore heavy crops, have been gradually going back, until they finally yield only gnarled and twisted apples, or in some cases, none whatever. Further investigation has shown that a number of orchards have grown up and come to bearing age without ever yielding a crop of fruit, or only fruit of the inferior kind already described. This state of affairs was all the more puzzling to the fruit-growers, since such trees almost invariably came into blossom each year. The most common complaints have been regarding the non-bearing of the Nonpareil (Roxbury Russet), but examination showed that the trouble was not by any means confined to this variety, though it undoubtedly suffered as severely, or more severely, than any other.

No one appears to have suspected that the trouble in the apples had any connection with that of the pears, or that either was of insect origin. In June, 1914, the writer visited an orchard near Wolfville, N. S., consisting of mature trees of various standard varieties, including Nonpareils, Ribston, Gravenstein, Golden Russet, as well as several varieties of pears. The owner stated that the orchard had been gradually going back for the past ten years, that for at least six years the Nonpareils had borne no crop, and that the trouble had gradually spread to the other varieties, until they too had ceased to bear. Some years before a number of pear trees had been cut down, because the fruit persisted in "growing woody", and those that remained were all going the same way every year. All the ordinary sprays had been tried, various fertilizers were applied, and the orchard under-drained in an effort to arrest the trouble, which, however, steadily grew worse. In fact, though this orchard was one of the best cared-for in the Valley and was formerly a splendid producer, it had at length reached the point where no crop at all was being produced. An examination of the trees showed them to be swarm-

ing with green nymphs of the insect now popularly known throughout the Annapolis Valley as the "Green Apple Bug", and a careful study of the feeding habits of the insect proved conclusively that it was the real culprit. For the past two seasons observations have been taken in many similar orchards throughout the province, and further investigations have only tended to confirm our earlier conclusions.

DISTRIBUTION AND SPREAD.

The pest seems to be well distributed throughout the fruit-growing centres of Nova Scotia and also where apples are not grown to any extent commercially. More or less severe infestations have been located throughout the counties of Hants, Kings, Annapolis and Digby, and typical "woody pears" have also been sent in from Prince Edward Island. It would at first seem that the pest was more widely distributed on pears than on apples, the phrase "injury to pears only" occurring with considerably frequency in the reports of the entomological inspectors. This, however, is probably due to the fact that whereas most of the injured pears remain clinging to the tree, the apples are largely destroyed while still in the blossom stage and later a large proportion of the injured apples drop to the ground.

Though experiments have shown that the adults are capable of flying considerable distances, the pest appears to spread but slowly from orchard to orchard. Orchards in close proximity to one another vary greatly in their degree of infestation. Continued observations have shown that a light but uniform infestation may suddenly develop into a very severe one, from one season to the next. Growers should therefore keep careful watch to discover any incipient outbreak before it has time to develop to such an extent as to menace the crop.

SERIOUSNESS OF PEST.

Sufficient has already been written to indicate that this insect is a very serious pest of the apple and pear, but any estimate of the actual damage would, of course, be out of the question. Though as yet many orchards are still free or comparatively free from attack, it is nevertheless a fact that where the green apple bug has become established, there is no pest to compare with it, either in the amount of damage done or in the difficulty that is experienced in controlling it. The pears in many orchards have for years been so scarred as to be quite

unmarketable and in numerous apple orchards the crop has been greatly reduced, or even destroyed. Further than this, the vitality of many trees has been seriously impaired and fruit spurs either killed or rendered useless from the attacks of the insect. Many growers who, two years ago never knew of the existence of the pest, will now state confidently that it is the worst insect with which they have to contend.

The apple crop in the Annapolis Valley has not been increasing at the rate one would expect from the new acreage constantly reaching bearing age each year. On the contrary, it seems to have, on the whole, actually gone back. There is little doubt in the mind of the writer that this condition of affairs can be to a large extent laid at the door of the green apple bug. In any case there can be no doubt that numbers of growers will have to abandon apple growing, if they do not bring this pest under control.

HOST PLANTS.

As far as we have determined, the insect only breeds in the apple, pear, quince, and possibly the rose. Young nymphs were found in considerable numbers feeding on rose bushes planted in sod, and about twenty feet from the nearest apple tree, but it is quite possible that the insects fell from the trees and made their way over the ground to the rose bushes. Nymphs were also found on a young elm tree beneath infested apples, but though elm trees are abundant near infested orchards, this is the only case in which we have found them infested by the insect.

When shaken from the tree, the nymphs have been observed to feed upon a large number of weeds and grasses growing beneath the tree, but on reaching the adult stage they invariably seek the apple, pear or quince to feed and deposit their eggs.

THE INSECT.

The young insects, or nymphs, are pale e[illegible]ghtly yellowish insects about 1-25 of an inch long when f[illegible] hatched. In the third nymphal stage they become a bright green and when full grown are slightly yellowish about the head and thorax, measuring about 1-6 of an inch long. The adult is a delicate insect ¼ of an inch long. When newly emerged it is quite pale in color, but later becomes a combination of light and dark browns, though individual insects vary greatly as regards

color. In appearance it bears a close resemblance to the tarnished plant bug (Lygus pratensis Linn), for which it is frequently mistaken.

LIFE HISTORY.

The first nymph to be found emerging in the orchard in 1915, was on May 24th, and the last on June 10th. In 1916 the first one was taken on May 18th, but they were not found hatching in numbers until May 24th, the date of maximum emergence being about the first of June. That is to say, the period of greatest emergence of the bug from the egg stage occurs just when the blossoms of the Gravenstein apple begin to open, or when the Bartlett pears are in full bloom. By far the greater number of insects hatch at this time, though a few belated individuals keep emerging throughout the blossoming period.

FIG. 1.

Condition of Gravenstein blossom buds when the first bug was found emerging in the orchard.

The nymphs seem to emerge simultaneously on both early and late varieties, but keep emerging for a longer period from late varieties such as the Nonpareil. The duration of the first nymphal instar is 5.22 days (average of 52 individuals); of second, 5.43 days (average of 34 individuals); of the third, 6.66 days (average of 34 individuals); of the fourth, 6.77 days (average of 24 individuals), and of the fifth, 6.83 days (average of 12 individuals).

In 1915 the first adults were taken on June 27th, most of the nymphs becoming mature by July 5th. In all the time that this insect has been under observation, no nymphs have been observed later than the first week in July, all having completed their transformation by that date. The length of the adult stage varies greatly, single individuals having been taken in the orchard as late as the last of September. During the season of 1915 adults were first taken on June 23rd, the greater number reaching the adult stage by July 3rd.

The accompanying table gives the details of the life history of 12 individuals which were reared from the egg stage to the adult stage during the season of 1915:

TABLE NO. 1.

LIFE HISTORY OF GREEN APPLE BUG IN 1915.

Number of insect.	Date of hatching.	Date of 1st moult	Date of 2nd moult.	Date of 3rd moult.	Date of 4th moult.	Date of 5th moult.	Date of death.	NUMBER OF DAYS SPENT IN EACH INSTAR.					Duration of nymphal stage	Duration of Adult Stage.	Total length of Life
								1st Instar.	2nd Instar.	3rd Instar.	4th Instar.	5th Instar.			
													DAYS	DAYS	DAYS
I.	June 1	June 6	June 13	June 20	June 27	July 4	July 8	5	7	7	7	7	33	4	37
2.	" 2	" 7	" 11	" 18	" 26	" 3	" 4	5	4	7	8	7	31	1	32
5.	" 4	" 8	" 15	" 22	" 29	" 6	" 10	4	7	7	7	7	32	4	36
11.	" 4	" 10	" 16	" 22	" 29	" 6	" 13	*11	6	6	7	7	32	7	39
17.	" 2	" 6	" 13	" 20	" 28	" 5	" 10	4	7	7	8	7	33	5	38
19.	" 3	" 8	" 15	" 23	" 30	" 7	" 11	5	7	8	7	7	34	4	38
21.	May 31	June 4	" 10	" 17	" 25	" 2	" 9	4	6	7	8	7	32	7	39
23.	June 2	" 7	" 13	" 20	" 26	" 2	" 8	5	6	7	6	6	30	6	36
27.	" 2	" 7	" 12	" 19	" 26	" 4	" 9	5	5	7	7	8	32	5	37
31.	" 3	" 9	" 16	" 22	" 28	" 5	" 14	6	7	6	6	7	32	9	41
33.	" 1	" 7	" 15	" 21	" 29	" 4	" 12	6	8	6	8	5	33	8	41
34.	" 3	" 9	" 16	" 21	" 28	" 5	" 10	6	7	5	7	7	32	5	37
					Averages			5.08	6.41	6.66	7.16	6.83	32	5.41	37.7

The duration of the nymphal stage in our open air insectary corresponds closely with that in the orchard, as proved by extensive observations, but the life of the adult insect under natural conditions is much longer than the insectary records would seem to indicate. Repeated experiments show that the adults will not thrive in confinement, but keep flying restlessly about, until they die of exhaustion. For the first week or ten days after emerging, the adults were abundant in the orchard, but from that time on they began to die off quite rapidly. It was an easy matter during this time to find a number of dead bugs fastened along the midrib of a single apple leaf. The bugs have a habit, when about to die, of extruding the caudal extremity of the alimentary canal, which is covered by a viscid secretion, by means of which they attach themselves to the leaf. This same habit was observed in the case of bugs killed by our sprays. A large proportion stuck themselves to the leaves in this way, and did not drop off on the sheets spread beneath the tree until some hours later.

Though large numbers of bugs died during the latter part of July, 1915, there was no difficulty in finding specimens through the month of August and early September. After that, individual specimens could only be located with difficulty. On August 27th 50 adults were collected, 46 being females and 4 males; on August 30th 50 more were collected, 45 females and 5 males; on Sept. 3rd collected 31 specimens, 27 females and 4 males; Sept. 9th, 10 insects collected, all females; Sept. 13th, 10 more specimens, all females, and on Sept. 17th only two adult females could be found. From that date until Oct. 7th scattering individual females have been taken. Similar observations were made in 1916, the adult insects being numerous for the first two weeks after emerging, after which they began to disappear, until by the end of July they were difficult to find.

EGG LAYING.

The eggs are deposited beneath the bark just within the cambium layer of pears, apples, quinces and possibly roses, commonly in the fruit spurs. By far the greater number are deposited in the twigs of the apple, even though other host plants are abundant. In many orchards suffering from a very severe infestation, we have failed to find any nymphs hatching on the pear trees, and while it is true that they frequently do breed in the pears, we have never found them in such immense

numbers as they are commonly found on the apple. Most of the egg laying is done during the month of July, but it continues through August and even later. The eggs are laid in fruit spurs, suckers, water sprouts and other twigs.

HABITS OF NYMPHS.

The immature insects, or nymphs, as they are called, of this species, are extremely elusive in their habits, which doubtless explains the fact that though their work has been known for many years they themselves have only recently been connected with it. When disturbed they run with great rapidity, hiding themselves in the axils of leaves, inside a curled leaf, inside the blossoms, between the blossom pedicels, or in any place that affords concealment. The young nymphs do not readily drop to the ground, and are not washed off to any great extent even by heavy rains, but, as they increase in size, they exhibit an increasing tendency to drop when disturbed. When trees infested with the bugs are sprayed at a time when the insects are over half grown, the backs of the horses are sometimes green with the nymphs that drop from the trees. Our observations show that first and second stage nymphs will run rapidly in an attempt to conceal themselves when disturbed, but will rarely drop to the ground unless forced to do so. Third stage nymphs show a tendency to drop, while fourth and fifth stage nymphs drop still more readily.

The newly hatched nymphs seem to prefer the foliage of apple and pear, but will also puncture the tender twigs, particularly suckers and water sprouts. As soon as blossoms and fruit are available the bugs cluster on them, though attacking freely any new leaves or shoots as they appear. Though we have reared the insect through to the adult stage exclusively on leaves, there is no doubt that blossoms and fruit are preferred, and they can only with difficulty be induced to feed on mature leaves. The fruit clusters are a favorite place for the nymphs to work and when the blossom pedicels are still fastened together they work their way in between them in large numbers for the purpose of feeding. As soon as the blossom petals begin to open out, and before they have spread apart, the young insects begin to make their way inside. After a heavy rain at this stage, it has been observed that the insects are apparently less numerous about the trees. A careful examination shows that large numbers of them have made their way into the blossoms, where they have hidden themselves among

the stamens. As many as eight nymphs have been found inside a single blossom. From this time on their attention is almost entirely confined to blossoms and fruit, the leaves and twigs, with the exception of the new growth, being altogether forsaken. Where the set of fruit on a tree is light, a very few bugs will soon destroy it all, and then, no further food being available, feed upon leaves and tender twigs. In feeding, the nymphs roam largely over the tree, especially when not numerous. Beneath a non-infested pear tree twelve fourth stage nymphs were liberated, and on examining the tree next day, their work could readily be detected over almost the entire tree.

Like many other Capsids, these insects sometimes exhibit predaceous habits. On one occasion a number of nymphs were observed repeatedly thrusting their beaks into the larva of a green fruit worm (Xylina sp.) that had been caught in a tanglefoot band, and continued to do so until the caterpillar had been sucked completely dry. Several have reported that they have been stung by the insects when passing beneath infested trees. If left undisturbed it will sometimes pierce the skin several times, and remain feeding until completely gorged with blood.

For such apparently fragile insects the nymphs are remarkably strong and active, and, as will be hereinafter explained, they are capable of making their way over the ground for comparatively long distances. They are also able to undergo somewhat prolonged periods of starvation. Living bugs have been found on twigs that were collected and kept without water for two weeks, though during most of that time it must have been impossible for them to extract any nourishment from the dead dry twigs.

HABITS OF ADULTS.

Like the nymphs the adults are very active, and they take to flight readily when disturbed. By standing in a heavily infested orchard on a bright day they can be easily observed flying about in the sunlight. Like the nymphs they are also very shy, and when approaching a tree where the insects are observed clustering on the fruit, they will be seen to make their way quickly around to the opposite side, and take to flight if molested further. In cold, dull or rainy weather they are more sluggish, and drop on slight provocation, though they usually take to flight before striking the ground.

PLATE I.

1

2

Fig. 1.—Appearance of apple seedling upon which a large number of bugs had been allowed to feed. Most of the leaves withered and dropped. (Original.)

Fig 2.—Check seedling. (Original.)

The prevailing opinion, which is supported by much indirect evidence, is to the effect that the pest spreads but slowly in an orchard. Nevertheless the adults appear to be comparatively strong flyers. Just how far they fly at any given time would be difficult to determine, but marked individuals have been found a quarter of a mile from the point of liberation some days later. Under natural conditions it is unlikely that the insects venture far afield from the orchard in which they have developed.

In feeding, the adult bugs will only have recourse to foliage when no other food is available, evidently preferring a diet of fruit, and they show a very marked preference for that of pears. As previously stated, pear trees, even in badly infested orchards, commonly escape serious injury from the nymphs. As soon, however, as the insects have reached the adult stage, they fly to the pears in great numbers, so that in a single day, what might otherwise have been a good crop, is rendered altogether unsightly and worthless. In certain orchards which have been under daily observation, pears have been examined bearing few or no signs of injury, which on the succeeding day would be found to be swarming with adult bugs and bathed in sap oozing from innumerable punctures. Experiments have shown that the adults will forsake all other food for the sake of feeding on a hard green pear. It may therefore be said that while the damage to the apple is mostly the work of the nymphs, the major part of the injury done to the pears is from the adults. It is a curious fact that after appearing suddenly on the pears in this way and feeding for a few days, the majority leave them as abruptly as they came and return to the apple trees, where, after depositing their eggs, they soon die. The adults will likewise freely attack the fruit of plums and cherries, though we have never yet found the insect breeding upon these plants, and do not know of them being attacked by nymphs except where they have fallen from surrounding apple or pear trees, and subsequently made their way up the trunks. In the latter part of the summer a common place to find the bugs is about the clusters of fruit that have been dwarfed by the Rosy Aphis (Aphis malifoliae Fitch) and here the adult may be found when nowhere else, late in the season. Such belated individuals show a preference for over-ripe or even decaying fruit.

Like the nymphs, the adults are frequently predaceous in habit, the writer having been stung on more than one occasion,

An adult was once observed with beak inserted in a full-grown tussock moth (Notolophus antiqua Linn.) larva, and only with difficulty could it be induced to relinquish its hold.

CHARACTER AND EXTENT OF INJURY.

1. Injury to the apple.

The first evidence of the insect's injury is found upon the young and tender foliage in the form of purplish spots upon the surface. This symptom is very characteristic and makes it possible to detect the presence of the insect almost as soon as it appears, and long before it would be noticed by the ordinary observer. Twenty-four hours after the insects hatch these spots are already quite marked. When the insect is present in large numbers the leaves exhibit a tendency to curl at the edges as a result of their work. As they unfold and increase in size the purplish discoloration gradually disappears, but if affected leaves are held to the light they will be seen to be pierced through and through with small holes, and in severe cases the leaf may present a very ragged and frayed appearance. By these symptoms the former presence of the bug upon the leaves may be detected, long after it has completed its transformations and disappeared.

The tender, succulent twigs of the current season's growth and even harder wood, is freely attacked, the point of puncture being often marked by a drop of clear or yellowish sap oozing through the bark. As the twig increases in size a decided lump develops at this point, and in rapidly growing shoots a longitudinal crack will sometimes appear. In heavily infested orchards, where the insect will be present in countless thousands, repeated puncturing of the twigs and withdrawing of the sap causes them to wilt, the leaves becoming brown and dry, and finally the whole shoot dies. Cases where a large proportion of the twigs are literally stung to death in this manner are a frequent sight in many orchards. In some cases the continued killing of the young growth year after year results in the death of even large limbs, and this, combined with the work of various wound parasites, may finally cause the death of the tree. Many cases have been observed where badly attacked trees have failed to make any appreciable growth for a number of years, so that it appears to be only a question of time before such trees will die. The fruit spurs in these trees seem to be particularly injuriously affected, so that a

large proportion of them appear to be quite dry and dead, though others might still be able to put forth leaves and blossoms. In cutting into these spurs, the effect of the innumerable punctures to which they have been subjected is at once apparent.

It is interesting to note that once the insects are destroyed, these trees take on a new lease of life. Trees that have been going back steadily for four or five years, when effectively sprayed for the insect, immediately began to send out a strong new growth, and apparently lifeless fruit spurs have sent out shoots twelve inches long, or more. It would doubtless be some time before these trees return to normal and the fruiting wood recovers from the injury it has received. Indeed, in many cases it will be necessary for new fruiting wood to be formed before a good crop can be expected.

In orchards where conditions are such that the trees are induced to make a strong, vigorous growth the effects of the insects' injury upon the trees themselves may be longer in making itself apparent. Frequently in places where the crop has been entirely destroyed, and much of the growth killed, the trees are able to send out a strong, rapid new growth, which, later in the season, completely conceals the injury that has been done.

As the blossom buds appear they are quickly attacked by the young nymphs, and these endeavor to force their way in between the blossom pedicels, upon which they feed. As soon as the blossom petals begin to open, but before they have spread apart, many of them work their way into the blossoms and conceal themselves among the stamens, where they have been observed with beak inserted directly in the pistil. Others have been observed to settle down on the floor of the blossom, and, inserting their beak in the receptacle, proceed to suck the juices of the plant. The tissue about the puncture immediately begins to turn brown, and, needless to say, the blossom eventually dies. When only moderately attacked the blossoms will usually drop to the ground, but when punctured by many insects, so that all the sap is removed, they sometimes become quite mummified and remain clinging to the trees throughout the summer. These facts explain why it is that badly attacked trees may come into bloom year after year, but never set a crop of fruit.

As soon as the fruit sets, drops of sap, oozing through the

skin, show that it also has been punctured by the insect. A slightly raised discolored spot or pimple develops at the point of puncture, and the young apple soon drops to the ground. Apples that are not attacked until a fair size, will usually remain on the tree, but are badly gnarled or misshapen. The tissue about the puncture fails to develop, and as a result of the uneven growth the apple will be one-sided, with a pronounced depression at the spot where the beak of the insect has been inserted. The puncture itself is marked by a brown corky scar and ruptured epidermis.

2. Injury to Pears.

Pear trees are rarely attacked as badly as apples by the nymphs, but they are frequently lightly, and rarely badly infested. The injury to the leaves, stems and blossoms resembles that to the apple, except that in this case the tissue about the puncture turns black. The stinging of the young pears does not commonly cause them to drop to the extent it does with the young apples, but the effect of the punctures on the fruit is conspicuous. Injured pears develop hard, corky, granular scars upon their surface, which may later split open, as in the case of the apple. Hard, flinty areas extend into the pulp, rendering such fruit quite unfit for use. Recent punctures are marked by oozing sap, as in the case of apples.

Numbers of old fruit growers tell of having seen this type of injury many years ago. Year after year, early in July, the pears would "leak" and later develop the characteristic scars. No one, however, as far as I am aware, suspected the real culprit, or noticed the damage done to the apples. This is due to the fact that the chief damage to the pears is done by adults, when the fruit is already well formed, and conspicuous injuries are thus brought about, but the trees are not seriously affected. In the case of apple trees, however, the greater injury is done earlier in the season to blossoms and very young fruit, which, as a consequence, never develops. In numerous instances much of this injury is attributed to frost.

3. Injury to Plum and Cherry.

Injury to the fruit of plums from the adult bugs is not uncommon, where these trees are in proximity to infested apples and pears. Plums injured by the bugs may be one-sided or misshapen, but the seat of injury is usually at the apex of the

fruit, such injury being marked by the exudation of colorless gum flowing out in the form of globules, or of a spiral coil, that finally hardens in the air. The injury done to cherries is very similar.

4. Injury to Quince and Rose.

The injury to both rose and quince so closely resembles that done to the apple that a separate description is unnecessary.

FEEDING EXPERIMENTS.

In infested orchards large numbers of nymphs are frequently shaken to the ground by sprays, heavy rains, wind, etc, and many drop with injured blossoms or fruit as it falls to the ground. In numerous instances such bugs have been observed feeding upon dandelions (Taraxacum officinale), couch grass (Agropyrum repens), red clover (Trifolium pratense) and various other plants growing at the base of the tree. Though we were able in no case to rear the insect from the egg to the adult stage upon these plants, nymphs of the third, fourth and fifth stages readily underwent the remainder of their growth upon various plants offered to them.

In 1915 a number of nymphs in their third, fourth and fifth instars were divided into lots of ten and placed upon various plants growing in the insectary. Some of each lot succeeded in reaching maturity, and the following observations as to their effect upon the plants were made:

Grape (Vitis vinifera).—The nymphs feed quite readily upon the grape, leaves, stems and blossom clusters being severely punctured.

Elm (Ulmus americana).—The injury to the foliage of the elm was noticeable in dark colored spots or blotches, but there was little or no twig injury.

Sugar Maple (Acer saccharum).—Injury to maple leaves was slight, appearing as small translucent spots. The insect did not feed readily upon this plant.

Sweet Cherry (Prunus avium).—A slight puncturing of the leaves and blossoms and gummy exudations from the fruit, but injury not pronounced.

Peach (Prunus persica).—Leaves showed plainly the effect of the insects' punctures, and small globules of transparent gum issued from injured fruit.

Strawberry (Fragaria virginiana).—Strawberries showed evidence of considerable injury; blossoms and leaves were so badly punctured that they finally withered and died.

Couch Grass (Agropyrum repens).—The injury to the blades of couch grass was marked, the plants becoming noticeably wilted and faded in color.

Dock (Rumex crispus).—Fed readily on the plant, puncturing leaves and fruit.

In the spring of 1916, 25 plants, common in and about orchards, were planted in pots in the greenhouse, and on each were placed five second and third stage nymphs, with the following results:

Plant.	No. Reaching Maturity.
Chickweed (Stellaria media)	2
Rose (Rosa rugosa)	1
Sweet Briar (Rosa rubiginosa)	2
Cultivated Strawberry (Fragaria virginiana)	4
Wild Strawberry (Fragaria chiloensis)	2
Buttercup (Ranunculus acris)	0
Dandelion (Taraxacum officinale)	1
Golden Rod (Solidago gramimfolia)	0
Golden Rod (Solidago graminifolia)	0
Broadleaf Plantain (Plantago major)	3
Narrowleaf Plantain (Plantago lanceolata)	2
Couch Grass (Agropyrum repens)	3
Daisy (Chrysanthemum leucanthemum)	1
Mullein (Verbascum thapsus)	0
Yarrow (Achillea millefolium)	0
Raspberry (Rubus strigosus)	3
Violet (Viola cucullata)	0
Orchard Grass (Dactylis glomerata)	3
Sheep Sorrel (Rumex acetosella)	2
Alsike Clover (Trifolium hybridum)	4
Red-top (Agrostis alba)	2
Dock (Rumex crispus)	2
Fall Dandelion (Leontodon autumnalis)	0
Total	40

We see from the foregoing that out of a total of one hundred and twenty-five, forty nymphs, or 32% reached maturity. This is no index, however, of the number that might come through under natural conditions, since the rearing of the insect, even on its natural food plants, is a matter of considerable difficulty, and accompanied by a high mortality. Furthermore the weather at the time was extremely damp, and moisture collected freely on the sides of lamp chimneys that were used to cover the plants.

THE GREEN APPLE BUG AND EUROPEAN CANKER (Nectria ditissima).

The European canker is very common in the orchards of Nova Scotia, working largely in the larger limbs, frequently causing their death. It appears that the damage from this disease is largely increased by the presence of large numbers of the green apple bug. In such cases it has been found that an undue amount of this disease is present in smaller limbs and twigs. The puncturing of the wood by the beak of the insect affords lodgement for the spores of the fungus, so that the life of many trees is actually menaced by the combination of these two pests. New cankers are commonly seen developing about the spot where the skin has been pierced by the insect.

Though the evidence that connects this insect with the disease is only circumstantial, it is sufficiently strong to indicate that the presence of this bug is an important factor in aggravating the damage done by this disease and in promoting its spread in the orchard.

That many insects are active carriers of various plant diseases has been demonstrated experimentally by various workers within recent years. Gloyer * and Fulton have recently shown that tree crickets (Oecanthus spp.) act as carriers of the fungus, Leptosphaeria coniothyreum, from raspberry canes to apple trees. In the same publication these writers also give a short review of the literature on the transmission of plant diseases by insects.

* Gloyer, W. O. & Fulton, B. B., Tree Crickets as Carriers of Leptosphaeria coniothyreum Sacc. and other Fungi. Tech. Bull. No. 50, N. Y. Agr. Exp. Sta. (1916).

The relation between the Lygus and Nectria is probably more indirect than the case just referred to. It is possible that some of the spores of the fungus may actually cling to the body of the insect, but its chief role consists in furnishing an opening for the entrance of the summer spores, which are produced abundantly throughout the season, particularly in damp weather.

THE GREEN APPLE BUG AND FIRE BLIGHT (Bacillus amylovorus).

The withering of blossoms and leaves accompanying the attacks of this pest were so strongly characteristic of fire blight that at first these symptoms were ascribed largely to this disease, and the bugs regarded as carriers. This is only what might be expected, since this correlation between the prevalence of fire blight and the presence of sucking insects has often been observed. Typical specimens of injured blossom clusters and twigs were accordingly submitted to leading authorities in the United States and Canada and the trouble diagnosed as fire blight. It soon began to appear, however, that the bug alone was responsible for much of the damage that has been attributed to the disease. In all our work throughout the Valley we never saw any signs of the blight except where the insect was present in large numbers, and its severity varied directly with the degree of insect infestation. Every blighted twig or shoot showed unmistakable signs of having been punctured by the insect. Only very rarely was the disease found to be running back into the previous year's growth, and in spite of a careful search, few so-called "hold-over" cankers could be found. It was found that new shoots generally arise from beneath the injured spur or twig, and the injured growth commonly, but not invariably, falls off before the end of the season. Furthermore, orchards that have suffered from the blight for years, show no signs of it when the insects are destroyed by spraying. We could always produce a blighted appearance on apple twigs by allowing a number of bugs to feed on them and, as similar symptoms have been observed to follow the attacks of aphids reared from the egg state in the laboratory, it would seem difficult, in many cases, to distinguish between the damage done by the disease and that due directly to insect punctures.

Specimens were accordingly submitted to Prof. V. B.

Stewart, Dept. of Plant Pathology, Cornell University, who has recently made a special study of the problem of fire blight transmission by sucking insects. Prof Stewart expressed the opinion that while a number of the twigs were unmistakably affected with fire blight, a large amount of the injury was caused by the insect alone. It would thus appear that, while it is often impossible by a superficial examination, to distinguish between the injury done by the bug and that occasioned by the disease, particularly in old trees where the blight does not extend down the trees for any great distance, it is not really necessary, from a practical standpoint, that such a distinction be made. Under Nova Scotian conditions fire blight on apples has not yet shown itself to be a serious disease. As far as our observations go, it is only with the presence of the insect, under favorable conditions, that it is able to make any progress, and once the insects are destroyed injury from this source ceases. Cutting out the diseased wood, as is commonly done for fire blight, would be useless in orchards infested by the green apple bug, where the unaffected twigs would soon be reinoculated by the myriads of insects that swarm over the tree. For all practical purposes, therefore, the fruit-grower can regard the bug as deserving of first consideration, and once that is destroyed he will probably find that the disease has disappeared also.

SUSCEPTIBILITY OF VARIETIES.

All those who have had the misfortune to have had an infestation of this pest in their apple orchards, agree that the Nonpareil (Roxbury Russet) suffers most. The infestation is invariably noticed first on these trees, and the bugs are almost invariably most numerous on this variety, though the Fallawater sometimes comes a close second. No variety, however, is altogether immune, and the common experience is that it will gradually enlarge its field of operations from the more to the less susceptible varieties. Ribstons and Golden Russets frequently suffer severely, while Gravensteins, Blenheims, Baldwins, and Greenings are also reported as being among the susceptible sorts. Once, however, the pest has become firmly established it is only a question of time before all other varieties are attacked.

Among pears, those of the Bartlett variety seem to suffer most severely. In fact, it has been believed in some sections that this trouble is a disease of the Bartlett pear, but observa-

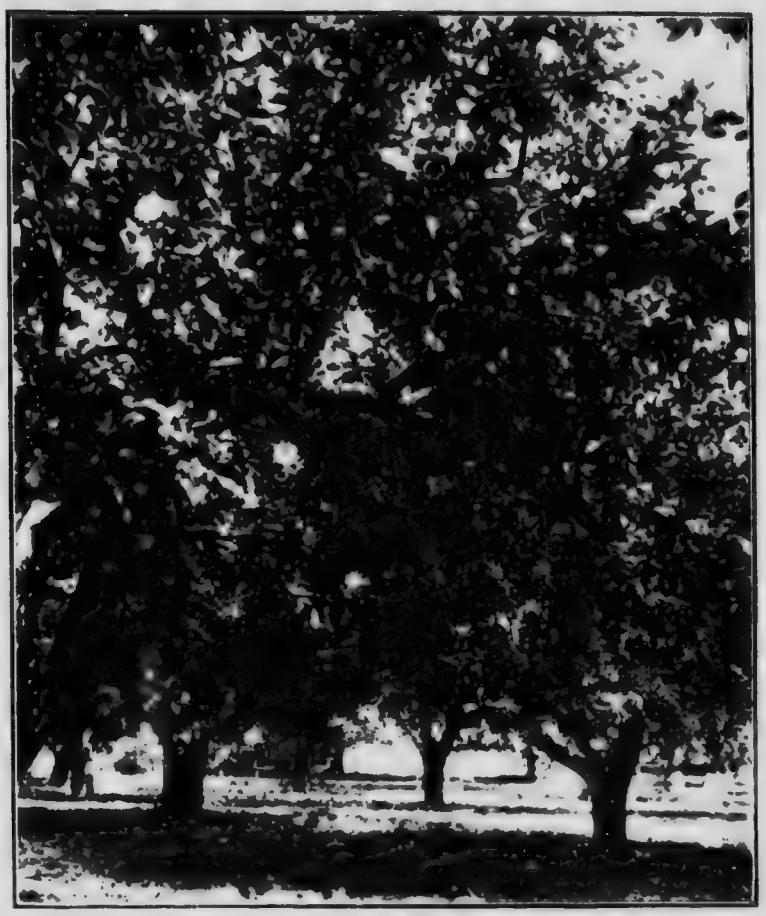
tion has shown that various others are frequently severely injured. Clapp's Favorite, Burbridge, Maria, and Flemish Beauty may be included among the susceptible varieties. Other kinds, which do not seem to be as badly attacked, are Louis Bonne, Bosc, Lawrence, Duchess and D'Anjou.

CONDITIONS FAVORING INCREASE.

It is difficult to state definitely under what conditions the insect flourishes best, since it is found in orchards that have been treated in every conceivable way. Sprayed and unsprayed, clean cultivated and sod, well cared for and neglected orchards are all attacked. It is a notable fact that many of the worst infestations are in orchards that have received the very best treatment in the way of spraying, fertilization and tilth. In most cases, however, such orchards were unduly shaded, being insufficiently pruned, too thickly planted, or both. Some of the orchards which have suffered worst have been cultivated on the strip system, i. e., with a strip of clover or grass alternating with a clean cultivated strip. In fact, a very large proportion of the worst infestations were found where there was a certain amount of growth at the base of the tree either in the way of sod or weeds. This may be due to the fact that in such orchards the large numbers of nymphs that invariably drop to the ground are liable to maintain themselves upon these plants and so reach maturity, whereas, under a rigid system of clean cultivation, many would be unable to reach the tree, while others would be destroyed by cultivation. It was also noticed that in low-lying ground, or where the orchard was screened from the wind, there the infestation was likely to be most severe.

As a result of extensive observations throughout the infested area, it appears that the most suitable conditions for the undue increase of this pest are shady orchards with closely planted, thickly growing trees, with poor air drainage, and a certain amount of herbage growing upon the ground. Healthy, vigorous trees, making an excellent growth, frequently suffer most, and, until weakened by repeated attacks, will put forth a heavy secondary growth to replace that destroyed by the bug. These foregoing factors are not, however, essential to a destructive outbreak, as the insect is capable of doing injury under a wide range of conditions. All the foregoing refers to apple orchards alone, though the same holds good, to a certain

PLATE II.



An orchard in which the bug has destroyed the crop for a number of years past. (Original.)

extent, of pear orchards. The proximity of badly infested apple trees is the most important factor in bringing about injury to the pears.

NATURAL ENEMIES.

Up to the present time we have not found any parasite that exercises any appreciable check upon the increase of the pest. Ants (Formica fusca Linn.) have frequently been observed carrying away the nymphs in their jaws from the trunks of the trees, and doubtless a large number are destroyed in this manner. On one occasion, when a number of nymphs were liberated at the base of a tree, four of them were seized by as many ants and carried off through the grass to the ant-hill, which was distant some fifteen feet. Spiders are also active in the destroying of the nymphs, but the percentage of mortality from both these sources seems to be comparatively small.

CLASSIFICATION.

This insect belongs to the Miridae (Capsidae) which constitute an important family belonging to the sub-order Heteroptera, order Hemiptera. This family is largely represented in our fauna and contains many forms injurious to plants, and others that are predaceous in habit.

The species herein discussed has been generally confused with related forms. Earlier workers doubtless mistook it for the common Lygus pratensis, while of recent years it has generally been referred to as Lygus invitus Say. Recently it has been described as Lygus communis n. sp. by Knight (14), and the Nova Scotian form as a new variety under the name novascotiensis (15). Accordingly, the full name of the insect is Lygus communis var. novascotiensis Knight. Parrott and Hodgkiss have proposed the name of False Tarnished Plant Bug for the typical communis, but the Nova Scotian variety is now well known in the province as the green apple bug, or simply as the "green bug."

DESCRIPTION OF LIFE STAGES.

EGG.—The egg is smooth and cylindrical, but curving slightly towards one side; constricted near broadened and flattened apex into broad neck, about which is a narrow collar, somewhat wider than the neck: base rounded, margins at centre slightly swollen. **Chorion,** delicate, coarsely punctured, translucent. **Collar,** whitish opaque. **Cap,** coarsely punctured. **General color,** pale yellowish white, translucent. **Length,** .752 mm.—.835 mm. Width, .195 mm.—.221 mm.

Nymph.—The nymphs resemble each other closely in general form, the first two nymphal instars being pale yellow in color and the last three green, with more or less yellow about the head and thorax. In the last two nymphal instars the wing pads are plainly visible.

FIRST INSTAR.—Body long, narrow; lateral margins narrowest at caudal margin of prothorax, thence widening very slightly to caudal margin of metathorax, and again to broadest parts at third abdominal segment. **Head,** more or less triangular, broadly rounded at apex. **Prothorax,** one-sixth longer than head and of equal width, excluding eyes; **Mesothorax,** of same length as the head, slightly broader than prothorax. **Abdomen,** pyriform. Entire dorsal surface covered with stout dark hairs regularly placed, and finer hairs irregularly placed, these hairs, like those on the femora, being three or four branched at the tip.

Antennae, medium length, stout, pubescent, with terminal segment more thickly covered with coarser hairs. Length *, .875 mm., 1st segment, .113 mm.; 2nd segment, .218 mm.; 3rd segment, .217 mm.; 4th segment, .327 mm.

Legs, long, fairly stout, clothed with fine hairs on tibia and tarsus. Stout hairs on femora. Length of hind tibia, .50 mm.

Color, whitish to pale yellow, rarely bright yellow; bright orange yellow spot on third abdominal segment. Legs and antennae translucent, tinged slightly with greenish yellow. Eyes bright red.

Length of Body, .857 mm.—1.185 mm.; width, .305 mm.—.407 mm.

SECOND INSTAR.—Body, broader and stouter than preceding instar, lateral margins narrowest behind eyes, widest at 3rd abdominal segment. **Head,** triangular, rounded before eyes. A few stout hairs placed regularly on cephalic margin and front. **Prothorax,** broad, equal in length to head, narrower at cephalic margin. **Mesothorax,** broader and shorter than prothorax. **Metathorax,** very slightly shorter and broader than mesothorax. Dorsal surface with few stout hairs, regularly placed. **Abdomen,** pyriform, bearing body hairs as on head and thorax.

Antennae, more slender than in preceding instar; clothed with fine hairs, especially on terminal segment. Length, 1.18 mm.; 1st segment, .137 mm.; 2nd segment, .35 mm.; 3rd segment, .3 mm.; 4th segment, .395 mm.

Legs, more slender than in preceding instar; femur bearing few long, stout hairs; tibia and tarsus clothed with fine hairs, particularly the distal extremity of the tibia. Length of hind tibia .75 mm.

Color, light greenish yellow, ingesta showing dark greenish through abdominal wall; usual orange spot on third abdominal segment. Eyes dull red; legs and antennae of a duller and lighter yellow than the body.

Length of Body, 1.28 mm.—1.375 mm.; width, .413 mm.—.557 mm.

THIRD INSTAR.—Body long, broad, flattened. Lateral margins narrowest behind eyes, thence diverging somewhat sharply to 3rd abdominal segment, thence tapering gradually to caudal extremity. **Head,** similar to preceding instar. **Prothorax,** equal in length and slightly broader than head, widening towards caudal border; caudal margin slightly procurved. **Mesothorax,** one-half length of the prothorax, one-fifth broader. **Metathorax,** one-third shorter than mesothorax, very slightly broader. Caudal margin procurved. Mesothorax and metathorax projecting very slightly caudad at lateral angles. **Abdomen,** broad, flattened, first seven segments marginate. Entire dorsal surface covered with short, dark hairs, thinly and evenly placed, but relatively smaller than in preceding instars.

---

* The antennal measurements given are averages from several insects. There is considerable variation.

Antennae, slender, strong; covered with fine whitish pubescence. Length, 1.37 mm.; 1st segment, .147 mm.; 2nd segment, .438 mm.; 3rd segment .355 mm.; 4th segment, .430 mm.

Legs, slender, strong, clothed with whitish pubescence. Hind tibia .75 mm.—1.037 mm. long.

Color, pale green, slightly yellowish on head and thorax. Orange spot on 3rd abdominal segment. Antennae and legs pale dull yellow. Eyes dull red.

Length of Body, 1.56—2.29mm.; width, .712 mm.—.943 mm.

FOURTH INSTAR.—Body, long, broad, oval, flattened; lateral margins narrowest behind eyes, gradually widening to third abdominal segment. **Head,** triangular, rounded. **Prothorax,** broad, but narrower than head; equal to head in length; lateral margin slightly divergent; lateral angles of mesothorax and metathorax projecting caudally, forming small wing pads, reaching almost or quite to third abdominal segment. **Abdomen,** broad, flattened, pyriform. Dorsal surface smooth.

Antennae, long and slender. Length 2.73 mm.; 1st segment, .30[illegible] mm.; 2nd segment, .936 mm.; 3rd segment, .708 mm.; 4th segment, .780

Legs, long and slender; hind tibia 1.48—1.6 mm. long.

Color, green throughout. Yellowish in head and about wing pads. Legs and antennae pale dull yellowish. Usual median abdominal spot yellowish.

Length of Body, 2.75 mm.—2.97 mm.; width, 1.107 mm.—1.16 mm.

FIFTH INSTAR.—Body, long, elliptical, broad and flattened; lateral margins narrowest behind eyes, curving gently to caudal margin, the widest part being just half the length of the body. **Head,** as in previous stages, but relatively smaller. **Prothorax,** equal in length to head; anterior margins divergent caudally. **Mesothorax,** one-sixth shorter than prothorax. **Metathorax,** one-fourth length of mesothorax. Wing pads long, rounded, extending almost to caudal margin of fourth abdominal segment. **Abdomen,** pyriform, slightly marginate. Dorsal surface smooth.

Antennae, long strong. Length, 3.42 mm.; 1st segment, .387 mm.; 2nd segment, 1.267 mm.; 3rd segment, .985 mm.; 4th segment, .783 mm.

Legs, strong, clothed with hairs as in preceding instars. Hind tibia .295 mm.

Color, pale green; apex of head, margins of wings and margin of thorax yellow; shortly before moulting the wing pads become dark brown at the tips. Eyes greenish white, but seen under the microscope the individual facets appear reddish brown at their centres.

Length of Body, 4 mm.—4.2 mm.; width, 1.62—1.85 mm.

ADULT.—The adult has been described by Knight (15) as follows:

"**Lygus communis var. novascotiensis** n. var. Paler and more slender than the typical communis, but not differing materially in the male claspers. Breeds abundantly on apple in Nova Scotia; but in New York I have been unable to take any form of communis on the apple.

Length, 5.3 mm.; greatest width 2 mm.; more slender and much paler than the typical communis; the two black rays on the pronotum small but distinct; hemelytra more yellowish brown than fuscous; lateral stripe of the body reddish or darkened with fuscous.

This is one of the varieties or races of communis which may be worked out from the forms inhabiting different plants, and perhaps influenced somewhat by different external conditions."

METHODS OF CONTROL.

Spraying Experiments in 1915.

Control experiments were undertaken during the season of 1915, though under most unfavorable conditions, the weather being almost continuously wet. This made it difficult to apply the spray at the proper time, or to observe its effect upon the insects. The orchard used for the purpose had suffered most severely for a number of years, and contained a fair representation of the leading varieties of apples and pears, most of which were severely attacked.

Nicotine sulphate (Blackleaf 40) was applied directly before and directly after the bloom, adding it to the regular lime sulphur spray. The pears were sprayed just after the blossoms fell and again about a week later.

At first the effect of the sprays seemed to be satisfactory, but subsequent examination showed sufficient bugs present to destroy practically the entire crop. As large numbers of dead bugs could be seen adhering to the leaves, and as all laboratory experiments showed that the material employed was effective in killing the insect when hit by the spray, even when in much weaker strengths than that used in the field, we were at first unable to account for this fact. It was soon discovered, however, that large numbers of nymphs were continually ascending the tree trunks from the ground, and subsequent investigation revealed the fact that even in unsprayed orchards large numbers of nymphs fall to the ground, shaken off by heavy rains, sprays or wind, or carried down by the dropping of injured blossoms or fruit. In many orchards that had not been sprayed at all, insects could be found in abundance beneath the trees and ascending the trunks.

Climbing of Trees by the Nymphs.

In order to determine to what extent nymphs were washed off during spraying, and whether any considerable portion of these succeeded in reascending the tree, one large tree was thoroughly sprayed with nicotine sulphate and soap, after having been banded with tree tanglefoot. Shortly after spraying the trunk of the tree beneath the band was swarming with the nymphs. These as a rule did not attempt to get over the band, and only a small number were actually caught therein. The bugs beneath the band were removed and counted each day for seven days, the total number taken amounting to 1389. Large

numbers also went up adjacent trees, 538 being taken from one of these, while many others could be seen feeding on the various grasses and weeds which were abundant in the orchard. It should be noted here, that these numbers represent but a very small proportion of the insects originally present on the tree, the dead bodies of which could be found in abundance sticking to the leaves or strewn upon the ground. Nevertheless, owing to the vast number of insects present and their tendency to seek out and feed upon the fruit, sufficient escaped to render the spraying futile.

It is only in the last three nymphal stages that the insect can readily make its way over the ground and reach the tree. First and second instars are likely to become engulfed in the small openings in the soil, and so perish. Moreover, the young nymphs do not fall to the ground as readily as they do in the later stages.

Mechanical Effect of the Spray.

To determine whether the effect of the spray was merely mechanical, and whether or not it might be possible to control the insect by a heavy spray of water alone, another badly infested tree was given a strong spray of water, using a Friend "drive" nozzle and a pressure of 200 lbs. In this case the total count over several days amounted to 308, and an examination of the tree showed that there was no appreciable diminution in the number of insects present. This showed conclusively that the insects do not drop to the ground with sufficient readiness to enable us noticeably to reduce their number simply by forcing them from the trees by a strong spray. It also showed that there was something besides mere mechanical effect responsible for the large drop from the tree sprayed with nicotine sulphate. The insects at this time were in their last nymphal stage, and it may be that many of them were only partially covered with the spray, and accordingly only temporarily overcome. It is possible that the effect of the nicotine fumes is to make the insect relax its hold and drop to the ground. Some experiments conducted last season seem to indicate that the fumes of the nicotine sulphate were themselves deadly to the insect, but later experiments undertaken on a large scale disproved this. In any case it is always true that a large number of nymphs fall to the ground, and of these a considerable proportion again make their way up the tree. The larger the nymphs the more readily does this dropping occur, and the sooner the spraying is done after they hatch, the smaller the

numbers that will be found making their way up the tree. It is obvious, from the foregoing facts, that in order to control this pest successfully, something must be done to prevent the reascent of nymphs which have fallen to the ground.

Distance Travelled Over the Ground by Nymphs.

Experiments were undertaken to determine the distance that nymphs were able to travel over the ground. In an orchard that had not been cultivated for several days, four trees, 30 ft. apart each way, were banded with tree tanglefoot and 300 fourth stage nymphs liberated between them. The next day 19 insects were taken from beneath the bands. A similar experiment was tried in an orchard which had just been cultivated, 150 nymphs being employed. In this case 17 insects reached the tree. This experiment was repeated in a sod orchard, 300 nymphs being used. By the next day none had reached the tree, though subsequent experiments and observations have shown that they are capable of making their way over sod ground for even greater distances. The tendency in such cases, however, is for the bugs to remain feeding upon the grasses and weeds.

Spraying in Conjunction with Banding.

Though at the time when the foregoing facts were discovered it was too late to save the crop, since the blossoms were already irreparably injured, it was determined to test the effect of banding the trees with tanglefoot before spraying. A badly infested block was accordingly picked out, some of which were banded, others left unbanded as checks. A heavy drench-spray of nicotine sulphate was next applied to all the trees. An examination the following day revealed large numbers of bugs present beneath the bands, but few or none could be detected on the banded trees. On the unbanded trees, however, there was a steady stream of nymphs ascending the trunks, so that in the course of a few days they could be found in all parts of these trees.

Spraying in Conjunction With Cultivation.

Other trees were sprayed and the ground beneath them immediately given a thorough harrowing. It was found that this gave practically the same results as banding, so that if an extra team were available to follow behind the spray machine banding would not be necessary.

It was also found that whether banded or not, the orchard must be cultivated, subsequent to spraying, in order to destroy the weeds and grass at the base of the trees, as the nymphs are capable of completing their development upon such plants. Cases have been noted where the good effects from spraying and banding have been rendered worthless from the insects flying up and attacking the fruit and ovipositing in the twigs, after having come to maturity on weeds growing in the orchard. This was found to be particularly true of pears, which are especially attractive to the adult insects. A row of Bartlett pears, growing in sod, was cleaned of the insects by carefully spraying and banding. As soon, however, as the adults appeared they flew to the pears in large numbers, as many as 18 being found on a single small fruit. In this case, many of the bugs came from nearby apple trees, but numbers of them were those that had completed their development on the grass and weeds.

Lessons Learned from 1915 Experiments.

The work of 1915, while failing to control the insects in the orchards treated, before they had practically completed their damage, pointed plainly to the methods which must be adopted to attain success. It showed clearly that the pest was a most difficult one to control, and that a very thorough spraying once before and once after the blossoms would have to be applied in order to destroy as many of the nymphs as possible. It taught us that it was next to impossible effectively to spray thickly growing, or very high trees, and that a good pruning should be a necessary preliminary to any attempt to eradicate the pest in the orchard. Furthermore, it was shown that trees must be banded with tree tanglefoot before spraying, or else cultivated immediately afterwards, to prevent the ascent of bugs from the ground, at least in cases of severe infestation. Lastly, it indicated that such orchards must be kept in a state of clean cultivation until all the insects have reached the adult stage.

SPRAYING EXPERIMENTS IN 1916.

With the foregoing facts before us, we were able in 1916, to proceed intelligently with the control of the pest. Two of the worst infested orchards of moderate size to be found in the Annapolis Valley were chosen for this purpose.

Orchard No. 1.—This is a four acre block and situated at Hortonville, Kings Co. It was at one time a heavy bearer, but the crop has been rapidly falling off of late years. The injury to the pears has been long noticed, but the injury to the apple was not detected until about five years ago, when it was noticed in a Nonpareil tree in a corner of the orchard. In 1911 the few Nonpareil trees in the orchard bore thirty-eight barrels of apples, the next eight, and since then none at all. Not only was the crop destroyed, but the trees themselves have been very seriously injured, the limbs being covered with fruit spurs which were to all appearances dead, as a result of the insect's work. Even though the pest is kept down in succeeding seasons, it will be some time before these trees have recovered from the damage that has been caused them. Though the damage to other varieties was not so great, the Gravensteins, Russets, Baldwins, Ribstons, etc., had also suffered to a considerable degree, the trees being weakened and the crop destroyed to a greater or less extent.

The trees were pruned as much as was considered safe, and, where necessary, were headed back to facilitate the action of the spray; the trees were banded with tree tanglefoot and the orchard cultivated at intervals until the end of the first week in July. Careful examination of the trees showed the bugs to be present in large numbers, as many as twenty- wc having been taken from a single blossom cluster while twelve or thirteen were common, and five or six the general rule.

The first spray was commenced when the Gravensteins were just beginning to open, using nicotine sulphate (Blackleaf 40) 1 pt. to 100 gals. of regular summer lime sulphur spray. The early varieties were sprayed first, our aim being to treat each variety just as late as possible before it came into bloom. A Friend "drive" nozzle was used throughout, and the most thorough work possible was done. This task was rendered much simpler by the pruning which the trees had previously received.

Towards the end of the first spray the bugs began to fall from the tree in increasing numbers and to cluster beneath the tanglefoot bands. Only a few, however, actually became entangled in them, as most of them, after wandering over the base of the trees for a few hours, left it for nearby weeds, where they were later destroyed by cultivation. The application of the second spray was commenced when about four-fifths of the

blossom petals had fallen to the ground. The same materials were used except that flour paste was added as a spreader over a portion of the orchard.

Orchard No. 2.—This is a six acre orchard located at Clarence, Annapolis Co., and like the other was formerly a heavy bearer, but, though only the crop of the Nonpareils had been completely destroyed, the percentage of No. 3's and culls on the other varieties, had been growing rapidly. There are 82 Nonpareil trees in this orchard, which in 1911, the first year of which we have any record, produced 550 bbls. of fruit, this reduced in 1915 to about 1½ bbls. of worthless cull apples. In that year, according to the owner's statement, "the horse ate the entire crop of Nonpareils." Though the owner has been able by good treatment to maintain the crop on the other varieties more nearly at the same level than in the case of the Nonpareils, a large percentage of them are so misshapen as to be entirely worthless. The number of 3's and culls has steadily, with some variation, increased from 40% in 1911 to 86% in 1915. Though factors other than the bug were in part responsible for the production of 3's and culls, their steady increase can be largely attributed to this source. These figures do not, of course, take any account of the loss in vigor occasioned the infested trees by the work of the insect, which, even with the best of treatment, will take some years to restore. The damage done to the trees in this orchard was most noticeable in the Nonpareils, as in orchard No. 1. Nevertheless the damage done to other varieties was rapidly increasing.

The spraying in this orchard was done on the same plan as in orchard No. 1, except that soluble sulphur was used in the second bug spray, and the nicotine solution added to this compound. A soft fish-oil soap was added to a portion of this spray to act as a spreader. For this reason we added no arsenical; but, as the bud moth and other biting insects had been controlled by previous sprays, and as the codling moth is not a serious pest in the locality, we were quite safe in doing this.

After the first four days of spraying the bugs began to drop from the trees in large numbers, seven hundred being taken from the base of one which was badly infested. These, however, soon left the tree for the weeds, where later the cultivator destroyed them.

TABLE NO. 2.

STATEMENT OF CROP PRODUCED IN ORCHARD NO. 1.

	No. bbls. Nonpareils.	No. bbls. other varieties.	Total No. bbls. produced.	% of 1's and 2's packed.	No. bbls. 1's and 2's packed.	No. bbls. 3's	No. bbls. culls.	% of 3's and culls.
1911	38	no record	.....	.....	.....	.....	.....	.....
1912	8	"	.....	.....	.....	.....	.....	.....
1913	none	"	.....	.....	248	146	.....	.....
1914	none	270	270	64%	121	96	.....	.....
1915	none	115	115	46%	173	64	33	46%
1916*	11	342	353	80%	53	53	9	64%
					282	67	4	20%

TABLE NO. 3.

STATEMENT OF CROP PRODUCED IN ORCHARD NO. 2.

	No. bbls. Nonpareils.	No. bbls. other varieties.	Total No. bbls. produced	% of 1's and 2's packed.	No. bbls. 1's and 2's packed.	No. bbls. 3's and culls.	% of 3's and culls.
1911	550	850	1400	60%	840	560	40%
1912	30	370	400	50%	200	200	50%
1913	40	360	400	20%	80	320	80%
1914	10	400	500	30%	150	350	70%
1915	1½	448½	450	13½%	60	390	86 2/3%
1916*	105	641	746	79.4 %	592	154	20.6%

* The figures for 1916 were compiled before all the grading had been done. Sufficient had been counted, however, to give an accurate estimate.

Results of Spraying.

The result of our spraying was a success as far as killing the insects was concerned. A few insects naturally escaped unharmed, as in all field experiments, but their numbers were inconsiderable, and they were unable to cause appreciable damage. The spreaders were found to increase the effectiveness of the spray, and to enable the same amount of material to cover considerably more surface.

The pears in the sprayed orchards were carefully watched as soon as the adults began to appear. The condition of the pears would form a good indication of the success of the work, since any insects left would be certain to seek out and puncture this fruit. For the first five days after the adults began to appear scarcely a winged bug could be found in either orchard, but finally they began to appear, though in small numbers. It is known that the adults are strong fliers and that they are attracted to the fruit of pear for considerable distances. That these bugs flew in from neighboring unsprayed orchards is made evident by the fact that in orchard No. 1, where the pear trees were scattered all through the orchard, only those on the outside suffered to any extent, those at the centre being practically unharmed. The production of perfectly clean pears in infested localities requires the virtual extermination of the pest, not only in the pear itself, but in all surrounding apple trees. Though the owner of orchard No. 2 had not picked any marketable pears for the past three years, this year fifty-two bushels of fine smooth pears were gathered, as well as four bushels, more or less damaged by the bug, but practically all saleable.

The chief benefit to these orchards was undoubtedly done by the spray before the blossoms. A careful search was made in both orchards, before the second spray was applied, and it was found that scarcely enough insects had escaped after the first spray, or hatched out afterwards, to warrant the application of a second. Nevertheless, in order to perfect our work, a second spray was given.

Tables number 2 and 3, while incomplete, will give an idea of the crop in the orchards sprayed for the past few years, as far as records have been kept. It should again be noted that maximum results in crop production cannot be expected until the trees have had a chance to recover from the injury they have received. This is true of orchard No. 1, where the

TABLE NO. 4.

TABLE SHOWING INJURY TO FRUIT FROM VARIOUS PESTS.

Orchard	Variety	Amount counted	Green Apple Bug	Apple Scab	Fruit Worms	Bud Moth	Codling Moth	Aphids	Tussock Moth	Miscellaneous	Clean
No. 1	Gravenstein.	5000 apples	% 1.2	% 3.7	% 1.04	% .64	% .16	% .08	% .06	%	% 93.12
No. 1	Pears	52 bushels	7 69								92.31 *
No. 1	Nonpareils	2500 apples	2.2	0.6	1.36	1.2	.068	.04	.02		93.36
No. 2	Gravensteins	1500 apples	1.46								98.54 *
No. 2	Kings.	1000 apples	2.2	12.2	0	.8	.2	0	0	9.4	77.4
No. 2	Nonpareils.	1000 apples	6.4	3.8	.2	1.8	.2	0	0	.7	87

* Counts were made for Green Apple Bug only.

Nonpareils, particularly, were so weakened that growth had ceased and the trees had practically no bearing wood left capable of even putting forth blossoms. In orchard No. 2 the trouble was further complicated by a bad infestation of European Canker (Nectria ditissima), so that between the injury due to the bug and that due to the disease, some of the trees were practically destroyed. All of them, however, showed an astonishing power of recuperation, and another season or two should bring them back to their former healthy condition.

Table number 4 will be of interest as showing the various pests that attacked the fruit, causing a proportion to be placed in the lower grades. Neither orchard received any treatment other than already described, with the exception of the Gravensteins, which were given an extra spray with lime sulphur by the owners.

Miscellaneous Spraying Experiments.

In addition to the foregoing main experiments, several others were performed on a smaller scale, just sufficient trees being sprayed to give us a fair test.

(a) **Different times of spraying.**—A single spray, using nicotine sulphate in the regular strength was applied in five distinct periods in the development of the blossoms:

(I.) When the blossom petals began first to show pink, but while the pedicels were still fastened firmly together. (See Fig. 1).

(II.) When the blossom petals were showing pink and after the pedicels had separated. (See Plate 3, fig. 1).

(III.) When the blossom petals had partly opened, but before they had spread apart.

(IV.) In full bloom, in which case the poison was left out so as not to injure visiting bees.

(V.) Just after the blossoms fell. (See Plate 3, fig. 2)

(VI.) One week after the blossoms fell.

In the case of spray No. 1, it was necessary to do the most thorough work possible in order to secure results Furthermore, where the early varieties were sprayed in this stage the number of new insects that hatched subsequent to the applica-

tion, were sufficient, in some cases, to nullify the results. This is, therefore, not an ideal time to spray, but if great care is used, fair results can be obtained, with the later varieties. No. 2 is the ideal time for the first bug spray, and ordinarily it gives a reasonably good control of the pest, even when no other is given. A certain number of insects, it is true, hatched after this spray was applied, but, for the most part, they did little damage except where the set of fruit was light. In these cases it was found that even a comparatively small number of insects would seek out and destroy all of the few apples on tree. Spray No. 3 was, in most cases, ineffective. With Gravensteins and other early varieties, it gave good results, for then the insects were not large enough to force their way inside the blossoms, but with Spys, Nonpareils, and later varieties, a proportion of the insects were large enough to force their way into the blossoms between the petals. Hidden inside the blossom, no spray could reach them. Spray No. 4 gave good results as far as the killing of the bugs was concerned. Where very numerous, however, they did a considerable amount of injury to the blossoms before it was applied. Spraying in full bloom is not recommended to orchardists, but was added to make our series complete. Large numbers of bugs fell from the trees during this spray. As for spray No. 5, while it was not found impossible to destroy the insects at this time, the task was rendered more difficult by the greater size and toughness of the insects and by the foliage affording more protection. It was found essential to do extra thorough work and to use a stronger solution than was necessary in the preceding spray. Furthermore, considerable damage had already been done to trees where the insects were plentiful. Spray No. 6, and all subsequent spraying were ineffective, not only because of the greater size of the insects and the greater protection of the leaves, but because the fruit clusters at this time were found to be irreparably injured.

(b) **Materials & Nozzles.**—The following materials were tested:

(I.) A combination of fish-oil soap, carbolic acid, and soluble sulphur, sold under the trade name of "Cylla-afis." To a portion of this material Thomsen's "Triplumbic" arsenate of lead was added as a poison.

(II.) A spray made from the following formula:

Soluble sulphur	2½	lbs.
Fish-oil soap (soft)	19	lbs.
Crude carbolic acid	1	pt.
Water	160	gals.

To a portion of this preparation we added triplumbic arsenate of lead as a poison.

III.) Fish-oil soap (Soft) used in strengths varying from 1-6 to 1-10; both alone and with soluble sulphur.

(IV.) Laundry soap (hard) used as above.

(V.) Nicotine sulphate (Blackleaf 40) was used in strengths varying from ½ pint to 1 pint for each 100 gals. of spray. It was used alone and in combination with lime sulphur, soluble sulphur and barium sulphur. To a portion of each of these combinations flour paste was added as a spreader, and in the case of the soluble sulphur combination, soap was also tested for this purpose.

Each separate combination was divided into 2 parts and applied, one using a Friend "drive" nozzle, and the other using a "calyx" nozzle. The results showed that the type of spray nozzle employed had a great deal to do with the success or failure of any material used. To destroy the insect the spray must come into contact with it and preferably strike it with force. It is therefore not surprising that none of the materials used gave altogether satisfactory results with "calyx" nozzle. The wide spray thrown by these nozzles, and the mist spray given by others in common use, is not adapted for driving the liquid in between the blossom pedicels, curled leaves, etc., in the same way as the strong, narrow spray thrown by the drive nozzle. This is particularly true in the after-blossom spray, owing to the greater size and density of the foliage, but is quite noticeable in that applied before the blossoms. The only really satisfactory results were obtained by this type of nozzle. Fair work may be done with the ordinary nozzles if extraordinary care is taken, but the greater amount of time necessary, as well as their undoubted inferiority for this work, counts against their use.

Sprays No. 1 and 2 gave good results, even when the insects were half grown or over. It is interesting to note that these two sprays acted as a strong repellent to biting insects.

Various caterpillars, offered leaves covered with these preparations, refused to feed upon them and so starved to death. An exception was the canker worm (Alsophila pometaria) which, however, did not feed as readily as upon unsprayed leaves. The soap sprays were fairly effective against the very young insects, but when used in the after-blossom spray, did not give as satisfactory results. Nicotine sulphate in the weaker strength used gave fair results against newly hatched insects, and at ¾ pint to 100 gals. was quite satisfactory for the first spray, when properly applied. It seemed to work equally well with lime sulphur, barium sulphur and soluble sulphur, possibly with a slight advantage in favor of the latter on account of its better spreading qualities. Soap made an excellent spreader, enabling the same amount of material to go much further. The same may be said of flour paste, which is also valuable as a sticker, holding the poison and fungicide on the tree long after they have been washed off elsewhere. Both of these materials increase the efficiency of the spray and make it possible to use the nicotine solution somewhat weaker than ordinarily recommended, provided the work is done with sufficient thoroughness.

(c) **Use of Different Pressures.**—Pressures of from 100 to 275 lbs. were tested, using drive nozzles and nicotine sulphate, 1 pint to 100 gals.

It was found that we could not get the type of spray desired by a lower pressure than 175 lbs. Whenever it dropped below that point living bugs would be found after the spray was finished. The efficiency fell off as the pressure decreased and became greater with the increased pressure. Good work was done at 175 lbs., but higher pressures gave even better results. Better results were obtained where one man worked with a pressure of 200 lbs., than where two attempted to spray using only 150 lbs.

(d) **Spraying Without Banding.**—Blocks of trees were sprayed and banded in the regular manner, but strips of sod or weeds were allowed to grow beneath the trees. In such cases injury was done by the adults which came to maturity on these plants, wherever the pest was numerous. Pears suffered especially from their work. This was done in a heavily infested orchard. When tested with a light or moderate infestation, and also in a small orchard where the spray could be applied at just the correct period, the benefit from banding was found to be inconsiderable.

CONCLUSIONS FROM CONTROL EXPERIMENTS.

1. Material to Use.

The most satisfactory material to use is nicotine sulphate (Blackleaf 40). The other materials experimented with, while effective, have not, at the present cost of the raw materials, any advantage in cost and are not so convenient to use. If properly applied a strength of $\frac{3}{4}$ pint for each 100 gals. will give excellent results.

2. When to Spray.

The ideal time for the application of the first spray is when the blossoms are showing pink, preferably after the blossom pedicels have separated, but before the petals have begun to open. Under field conditions this ideal is difficult to attain, but it is advisable to spray the earlier varieties first, since an application made at a time that would be effective on an earlier variety, such as the Gravenstein, would be too early for good results on a late variety, such as the Northern Spy. Medium to late varieties should be sprayed at an earlier stage of their blossoms than the earlier varieties, owing to the habit of the insect of entering the blossoms and concealing itself among the net-work of stamens. Gravensteins and other early varieties can safely be sprayed at a later stage of their development than late varieties, since the insect is too small at this time to enable it to force its way inside the blossoms. When, however, the blossoms of the late varieties begin to spread apart, preparatory to opening, some of the insects are larger and are able to force themselves into the blossoms. To obtain the best results, the first spray should be commenced just before the blossoms open, taking the earlier varieties first, and finishing up on the late ones. This spray, if timed properly, and done with sufficient care, will give practically a commercial control of the pest. Much better work can be done and a weaker solution used at this time than later, when greater protection will be afforded by the larger leaves.

Growers who are fighting this insect should therefore concentrate on this spray, and spare no effort to destroy every insect present on the trees. If this is done they need not, with an ordinary infestation, fear the few bugs that hatch subsequent to this spraying. Those who have only a very light infestation of the bug should not fail to give their trees the benefit of the

PLATE III.

1

2

Fig 1.—Condition of Gravenstein blossoms when first spray should be applied. (Original.)

Fig 2.—Condition of blossoms at time of second spray. (Original.)

spray before the blossoms. If applied in such a way as to destroy the green apple bug, aphids and other sucking insects will also be controlled, though this is not the ideal time to spray for these pests. This is also the most important time to spray for the apple scab (Venturia pomi), and a thorough drenching of the trees with fungicide at this time will be very beneficial in the control of this disease.

In order to catch those insects that have hatched during the blossoming period it is necessary to apply another spray after the blossoms fall. The foliage being much denser at this time the task is naturally more difficult, but with care excellent results can be accomplished. Where very severe infestations exist it will usually be advisable to apply this spray.

Though spraying in full bloom is not recommended, it is of interest to note that the pest was effectively controlled. Trees sprayed in bloom require no further treatment for the bug, which, however, if numerous, may accomplish considerable harm before this time.

3. How to Spray.

The control of the green apple bug is chiefly a mechanical problem, as has been previously intimated, and more depends upon the manner in which the spray is applied than upon any other factor. All parts of the tree must be reached and every insect covered with the liquid. For this purpose a strong, narrow driving spray is essential, best obtained in our experiments by the use of a "drive" nozzle and a pressure of 175 lbs. and upwards.

Control cannot be secured by spraying **at** the tree as is commonly done, or by going all around the outside and leaving the centre untouched. Every limb and twig must be followed up and down and sprayed from every angle, from below as well as from above. The nozzle should be thrust into the centre of the tree, and particular care should be taken to drench all parts. The tops should be given special attention, as the bugs are just as numerous here as anywhere on the tree. Thoroughness is the great secret of success in the control of this insect, ordinary spraying being of no avail, and it must always be remembered that the aim is to spray the insect, not the trees.

Some orchardists spray the entire orchard without ever

examining the trees to note the effect of their work. It therefore frequently happens that much valuable time and material is consumed before it is discovered that the whole has been wasted. It is very important to examine a tree here and there at intervals throughout the work, making certain that the spray is having the desired effect. If living bugs are still found on the sprayed trees, this indicates that still more careful work must be done. By following this rule the fruit grower will be saved much disappointment and loss.

4. Amount of Material to Use.

The amount of material to use naturally depends upon the size and thickness of the tree. Futhermore it is well to remember that good spraying does not consist in merely pouring out a certain number of gallons upon a tree. It is possible to use as much as 30 gallons on a moderate sized tree without it being effectively sprayed as far as the bug is concerned, whereas five gallons, properly applied, might have accomplished the work. Effective spraying consists in getting the liquid on the bugs and getting it there with force if possible.

At the same time, it may be useful to have a general idea of the correct amount of material to use. In our orchard No. 2, 3300 hundred gallons of material were applied to the orchard in the spray previous to the blossoms, or 12 gallons of liquid per tree, and in the spray after the blossoms 4400 gallons, or 16 gallons per tree. These trees, it should be remembered, were in a sixty year old orchard and were considerably larger than the average in size.

5. Importance of Pruning and Thinning.

Whatever views may be held as to the value of pruning and thinning from a horticultural standpoint, there is no doubt that it is essential to the successful control of this pest. Trees that are too thick to be readily accessible to the spray, or that are too high for all parts to be reached, cannot be successfully treated, and moreover, much material is wasted. No one should attempt to treat an outbreak of this pest in his orchard without having first attended to this imporant matter.

6. Necessity of Banding Trees.

The only practical way to prevent those bugs which have fallen to the ground from returning to the trees, is by the use

of tanglefoot bands. Could the spraying of the trees be followed by the harrow or cultivator, this might do equally well, but a second team is rarely available for this purpose. A wide heavy band is not necessary, since these insects do not bridge it after the manner of canker worms. In fact, only a small proportion ever stick to the band at all, which is only applied for the purpose of keeping them from climbing the trees. The spot which is to be banded should be first scraped with a blunt instrument, and a thin narrow band of the tanglefoot applied with a paddle. In very light infestation banding might be safely omitted, but in the experiments conducted in badly infested orchards, it was found to be essential.

7. Necessity of Clean Cultivation.

Nymphs dropping from the tree have been shown to be able to subsist on various plants and if prevented from ascending the trees, they will remain feeding on such plants until after they have reached the adult stage, when they will immediately seek the trees and continue to feed for some time upon the fruit. As has previously been pointed out, considerable damage is done to pears by the adult insects. While they are not so destructive to the apples in this stage, they deposit the eggs for next year and it is therefore most important that as many as possible of the insects be destroyed before they reach maturity. Since the adult stage is not reached by all insects until about the end of the first week in July, it is essential that sufficient cultivation to keep the weeds in check is given the orchard until this time is passed. This recommendation refers particularly to badly infested orchards.

8. The Use of Spreaders.

The material can be made to go further and made more effective by the use of spreaders. Flour paste is an excellent spreader and also causes the material to adhere firmly to the leaves, thus affording longer protection against fungi and biting insects. This material is prepared in a similar manner to that used for wall-paper. In making the paste a pound of flour is used for each gallon of water, the flour being first thoroughly screened so as to break up all lumps. It is then made into a thin batter with cold water, and stirred into the required amount of vigorously boiling water. It should then be removed from the stove and stirred until a paste is formed. The fore-

going method will usually give sufficient cooking to make a good paste, but it may be left on the stove a little longer if necessary, and stirred to prevent it from burning to the bottom. Insufficient cooking gives an ineffective paste, while over-cooking causes it to become hard and sticky, so that it will not mix with the water and causes the nozzles to clog. The paste should be added to the mixture through a sieve and any lumps should not be forced through by hand, but by the use of water. From 3 to 4 gallons to each 100 gallons of spray should be used.

Soap has also been used as a spreader and is excellent for this purpose. It should not, however, be used in combination with lime sulphur or with arsenate of lead or arsenate of lime, but with soluble sulphur it can be used with perfect safety. A combination of soluble sulphur and nicotine with a soft fish-oil soap added at the rate of 2 qts. of soap to each 100 gals., was used with excellent results.

9. Burning From Heavy Spraying.

It was found that lime sulphur was liable to injure foliage when used in the large quantities necessary in spraying for the bug. Since, owing to the lack of time, it is out of the question to make separate applications, we experimented with the lime sulphur in reduced strengths. It was found that by using commercial lime sulphur testing 33° Baume in the strength of from 1-50 to 1-70, the danger from burning was greatly reduced. It will naturally be asked whether these strengths are sufficient to control apple scab, since this disease is one of the main considerations in orchard spraying. We were somewhat surprised to find that trees sprayed with solutions as weak as 1-70 remained comparatively clean and free from scab. In fact they were in a much better condition than trees that had received only moderate spraying with strong solutions. No effort was made to determine the minimum strength to be employed for apple scab, since this was not the object of the investigation, but this season much weaker strengths than originally used were satisfactory, wherever the work was done in this thorough manner. Whether we would have obtained the same satisfactory results against the scab under conditions more favorable for the development of the fungus, still remains to be seen. It may be necessary to sacrifice something in the way of scab control in order to destroy the bug, except in small orchards where separate applications can be made.

Where nicotine sulphate was employed in combination with soluble sulphur, no poison being included, injury to the foliage did not result. The fish-oil carbolic mixture, used in combination with soluble sulphur, and "triplumbic" arsenate of lead, caused considerable burning, but little injury resulted where the arsenate of lead was omitted. No burning was caused by the Cylla-afis when used without an arsenical poison.

10. Cost of Treatment.

The cost of spraying will vary with the size of trees and the number of sprayings found necessary. The cost of nicotine sulphate (Blackleaf 40) at $10.75 per 10 lb. tin, for one spray in Orchard No. 2, amounted to $50.55, or approximately 18 cts. per tree. To this must be added 3½ cts. for the cost of tanglefoot for each tree. Thus the cost of material alone, to obtain a commercial control of the green apple bug, amounted to 21½ cts. per tree. For two sprayings of Orchard No. 1, the cost was slightly under 33 cts. per tree.

In considering these figures it must be remembered that we had to deal with unusually severe infestations and exceptionally large trees, and that, as we now know, we can safely weaken the strength of our mixture, particularly in the first spray, provided we do sufficiently careful work. Had we reduced the strength of the material in our first spray to ¾ of a pint for each 100 gals., the cost in No. 2 orchard, where the trees were largest, would have been reduced to 17½c. per tree In none of our work was any attempt made to save material, all our efforts being concentrated on the destruction of as many bugs as possible. Even with this, many may be inclined to ask if the cost is not excessive, in proportion to the end gained. Those who have spent large sums on their orchards for years past, in cultivation, fertilizing, underdraining, etc., only to see the crop fall off every year until it is finally greatly reduced, if not entirely destroyed, will not be likely to hesitate regarding this expenditure. The great difficulty lies in the fact that the absolute necessity for work of extreme thoroughness is seldom realized when the first attempt to control the pest is made. The result is that, not only the crop, but also the money spent in attempting to produce it, is lost. Where, however, the precautions outlined in this bulletin are faithfully followed the cost is inconsiderable when compared with the benefit to be gained. Many growers have now to decide whether they will have the best of their land encumbered with an unprofitable

orchard, or whether they will expend the time and money necessary to eradicate the pest.

11. General Considerations.

It will be seen from the foregoing discussion that the control of the green apple bug is no ordinary task. The time consumed in spraying for this pest is considerably greater than when it is only necessary to do ordinary work. It is therefore doubly important that the spray pump and engine should be in good order and that the facilities for filling, etc., are such that no time is lost. Many precious hours are wasted for the want of a little attention to the machine, before the spraying season commences. When the success or failure of a certain spray depends upon getting it on at a certain critical period no precaution should be neglected to prevent unnecessary delays. Some orchardists can fill their tank and mix their material in as short a period as ten minutes, while others require as long as forty-five minutes to an hour in doing the same work. Others have gone to the expense of purchasing a power outfit, but in place of a regulation tank make use of one or two 40 gal. barrels. This necessitates the same amount of work for every 40 gallons that it should take for four or five times the amount. Such delays as this make all the difference between profit and loss in spraying the orchard. With proper facilities and the use of drive nozzles, a good outfit should put out at least 1,000 or 1,200 gals of spray per day, but this will not allow much margin for tinkering with the outfit.

12. Causes of Failure.

Numbers of growers have attempted to control this pest without results commensurate with their expenditure and experience has shown that the neglect of some very slight precaution is often responsible for such failures. Some have failed to band the trees, others have not kept down the weeds, and these have had their efforts defeated by the insects which made their way back to the trees again. Many have not done the work with that thoroughness that is an essential to success. It is hard to make the average sprayer realize the amount of care necessary in order to have the liquid reach every insect. Others, who did the work as well and thoroughly as was possible under the circumstances, failed because they did not secure the right type of spray. These must remember hereafter that with ordinary mist nozzles and low pressures it is next to impossible to control the bug.

The statement has frequently been made that the coarse spray thrown by nozzles of the drive type is productive of wasted material. This type of spray, however, makes it possible to place the spray just where it is required and, if skillfully handled, should not result in undue waste of material. In forcing the liquid into all parts of the tree the outer leaves will naturally shed some of the material, which drops to the ground. This must simply be regarded as inevitable, for the man who is afraid of "wasting spray" is responsible for most of the failures to control the bug. That an adequate amount of material, properly applied, in conjunction with careful pruning, cultivation and banding, will control the pest, has been definitely proven, both by our own experiments and by the experience of several practical fruit growers.

ACKNOWLEDGEMENTS.

The author desires to extend his most hearty thanks to all those who have assisted him in any way throughout the course of this investigation. Messrs. H. G. Payne and W. E. Whitehead have helped in the study of the life history of the insect. Mr. L. G. Saunders is responsible for the colored plate and for general laboratory assistance. Mr. C. B. Gooderham assisted in the experimental work on various occasions, and most of the photographic work has been performed by him. The success of the spraying and other field experiments is largely due to the earnest, painstaking efforts of Messrs. J. P. Spittall and C. F. U. Whitman, who carried on this part of the work.

BIBLIOGRAPHY.

Owing to the fact that the Green Apple Bug has only recently been described, and is apparently confined to this part of North America, very little has been published regarding it. Owing to its very close relationship to the false tarnished plant bug (Lygus communis Knight), and the similarity of their work, references to this insect are likewise included.

1. **1886** Lintner, J. A.—Rept. Inj. Ins., N. Y. 3:110. 1885.
Describes injuries to pears which are attributed to L. pratensis, which are doubtless the work of communis.

2. **1891** Lintner, J. A.—Rept. Inj. Ius., N. Y. 7:348, 1890.
Describes work of Coleophora sp. to pears, stating in a foot-note that part of the injury was subsequently found to be in part the work of L. invitus Say. (?) No doubt the culprit in this case was also communis.

3. **1893** Lintner, J. A.—Rept. Inj. Ins., N. Y. : 288. 1891.
Note on damage done to pears by L. invitus Say, which is said to be widespread, but not serious. Describes work which he attributed to L. pratensis on pears in another locality, which reads like a description of what we now recognize as the injury of L. communis.

4 **1893** Riley, C. V.—Insect Life. 5:18.
Note on injury due to Lygus sp. at South Byron, N. Y.

5. **1900** Lowe, V. H.—Injury to peaches by the Tarnished Plant Bug, N. Y. Agr. Expt. Stat. Bal. 180:135.
Records injury to peaches which he attributes to Lygus pratensis, which might possibly have been mistaken for communis.

6. **1901** Howard, Dr. L. O.—U. S. Dept. Agr. Ent. Bul. U. S. 30:98.
A note recording attack of Lygus invitus on peaches the insect sucking the juice from the young fruits, causing them to shrivel. This is said to be the first record of injury done by the insect, with which the author is acquainted.

7. **1895** Slingerland, M. V.—Cornell Exp. Sta. Bul. 93:221.
Note on injury to pears characterized by "hard, knotty kernels, which are so often accompanied by irregular pustular spots or cracks." This injury was attributed to plant bugs (L. communis?) or the plum curculio.

8. **1910** Parrot, P. J.—Rept. of Inj. Ins. West N. Y. Hort. Soc. Proc. 55:114-119. Figs.
During 1909 it was discovered that gnarly pears, the fruit being stunted and irregular in shape and more or less marked with hard, corky spots, was caused by L. invitus Say. In one orchard 75% of the fruit was damaged, 50% being rendered useless. The insect referred to is communis.

9. **1913** Parrot, P. J. & Hodgkiss, H. E—The False Tarnished Plant Bug as a Pear Pest, N. Y. Agr. Exp. Sta. Bul. 368. (Plates 8; Figs., 7).
This is a 20-page bulletin containing a brief account of the history, injuries, habits, biology and methods of control of Lygus communis, which is referred to as Lygus invitus Say. A description of the different stages is given and the name, "False Tarnished Plant Bug", is proposed as a popular name for the insect.

10. **1915** Brittain, W. H.—Rept. Prov. Ent. Rept. Sec'y. Agr. 1914.
A brief note regarding discovery of damage done by the Green Apple Bug to pears and apples throughout the Annapolis Valley, N. S.

11. **1915** Knight, H. H.—Observation on the Oviposition of certain Capsids. Jr. Ec. Ent. Vol. 8, No. 2. : 296-297.
Describes the details of oviposition of a female Lygus invitus on a pear twig. The insect here referred to is L. communis and not the invitus of Say.

12. **1915** Brittain, W. H.—The Green Apple Bug. Proc. Ent. Soc. N. S. 1915. No. 1. : 43-47.
A summarized account of observations made regarding the insect during the year 1915.

13. **1915** Brittain, W. H.—46th Ann. Rept. Ont. Ent. Soc. 1915. (3 Plates).
More extended account of the studies made regarding this insect during the season of 1915.

14. **1916** Knight, H. H.—Lygus communis n. sp. Can. Ent. Vol. XLVIII., No. 10 : 346-348.
Original description of the species.

15. **1916.** Knight, H. H.—Lygus communis var. novascotiensis n. var. Can. Ent. Vol. XLVIII., No. 10. : 349.
Original description of the variety.

PLATE IV.

Fig. 1.—Injury to tender leaves. (Original.)

Fig. 2.—Mature leaves as seen when held to the light, showing effect of former injury by the bug. (Original.)

PLATE V.

1

2

Fig. 1.—New growth injuriously affected by nymphs of the Green Apple Bug. (Original.)

Fig. 2.—Apple twigs showing effect of former punctures. (Original.)

PLATE VI.

1

2

Fig. 1.—Blossoms destroyed by punctures of the bug. Photo taken two weeks after normal falling of the blossom petals. (Original.)
Fig. 2.—Uninjured fruit spur at the same period. (Original.)

PLATE VII.

Fig. 1.—Fifth stage nymph feeding on young apple. (Original.)
Fig 2.—The same seen from the front. (Original.)

PLATE VIII.

1

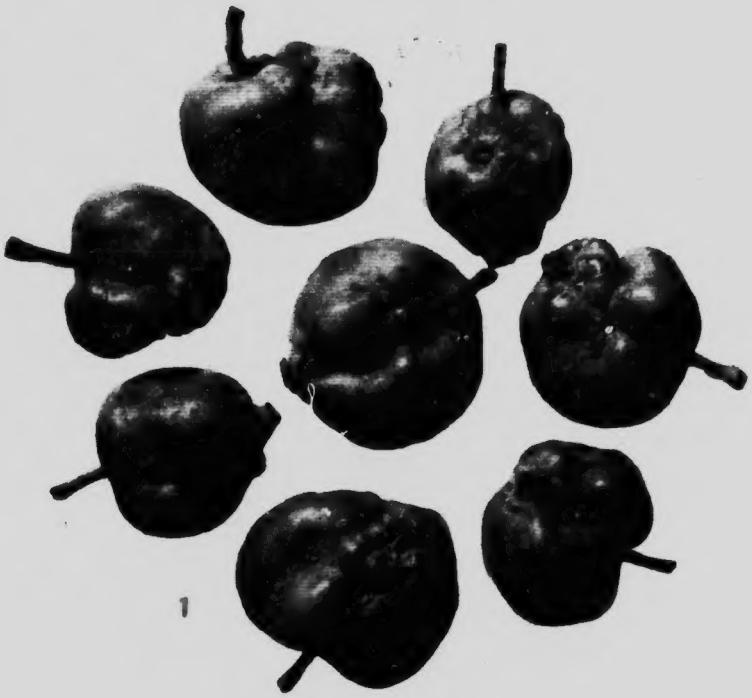
2

Fig. 1.—Fifth stage nymph and young pear injured by same. (Original.)
Fig. 2.—Adult bug and pear damaged by its punctures. (Original.)

PLATE IX.

Pears showing scars caused by the feeding punctures of the Green Apple Bug. (Original.)

PLATE X.



1

2

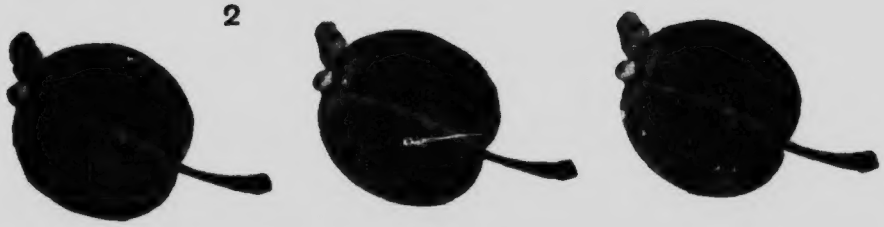


Fig. 1.—Apples three-quarters grown, showing early work of nymphs. (Original.)

Fig. 2.—Full grown plums injured by adults. (Original.)